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### Establishment of an imported natural enemy, *Neomusotima conspurcatalis* (Lepidoptera: Crambidae) against an invasive weed, Old World climbing fern, *Lygodium microphyllum*, in Florida

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## SHORT COMMUNICATION

### Establishment of an imported natural enemy, *Neomusotima conspurcatalis* (Lepidoptera: Crambidae) against an invasive weed, Old World climbing fern, *Lygodium microphyllum*, in Florida

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*Neomusotima conspurcatalis* established populations against *L. microphyllum* at three locations in Florida during 2008. A total of 31,091 insects were released. Ten months later populations estimated at 1.6 to 8.2 million larvae per site had defoliated over 14,000 m<sup>2</sup> of *L. microphyllum*. Findings look promising for biocontrol of *L. microphyllum* in Florida.

**Keywords:** *Lygodium microphyllum*; *Neomusotima conspurcatalis*; establishment

Old World climbing fern, *Lygodium microphyllum* (Cav.) R. Br. (Lygodiaceae), is native to wet tropical and subtropical regions of Africa, Asia, Australia and the Pacific Islands (Pemberton 1998) and was first found naturalized in Florida in 1968 (Beckner 1968). Over recent decades *L. microphyllum* has spread rapidly to infest large areas of seasonally wet habitat throughout southern and central Florida (Ferriter and Pernas 2006). *Lygodium microphyllum* competitively excludes native plants and changes local fire ecology (Pemberton and Ferriter 1998) and in so doing is altering the species composition of invaded ecosystems across large areas of south Florida. For this reason *L. microphyllum* is regarded as one of the most serious invasive weeds currently affecting the state (Volin, Lott, Muss, and Owen 2004).

*Neomusotima conspurcatalis* Warren (Lepidoptera: Crambidae) (Solis, Yen, and Goolsby 2004) is a multi-voltine member of the fern-feeding subfamily Musotiminae and was first discovered feeding on *L. microphyllum* in Hong Kong by Pemberton in 1997 (Pemberton, unpublished data). Subsequent foreign exploration discovered populations of *N. conspurcatalis* feeding on *L. microphyllum* in China, and throughout Southeast Asia into northern Australia. Comprehensive host range testing of *N. conspurcatalis* (Boughton, Bennett, Goolsby, and Pemberton 2009) demonstrated that this insect is restricted to the fern genus *Lygodium*. In 2006, following review of the data, the Technical Advisory Group (TAG) for biocontrol of weeds recommended release of this agent. An USDA-APHIS release permit for *N. conspurcatalis* was issued in late 2007.

Female *N. conspurcatalis* moths lay eggs on the upper or lower surfaces of *L. microphyllum* pinnules (leaflets). After hatch, young larvae feed by skeletonizing

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the undersurfaces of *L. microphyllum* leaflets, leaving behind distinctive 'clear windows' of epidermal cells. These 'windowed areas' soon become opaque and brown and eventually whole leaflets turn brown and die. Older larvae feed by skeletonizing or by consuming whole leaflets. When larval populations are large, pronounced foliage damage can occur, causing foliar browning of entire *L. microphyllum* plants. Larvae pupate in concealed locations among leaflet debris on the above ground parts of plants. Adults are small brown moths with a wingspan of about 11 mm, and have a distinctive white 'boomerang-shaped' marking at the tip of each forewing. Adults live for about 10 days in the laboratory and the complete life cycle from egg to adult takes about 30 days at 25°C. It is anticipated there will be 10–12 field generations per year in Florida.

*Neomusotima conspurcatalis* was first released in the United States during 2008 at Jonathan Dickinson State Park in Martin County, in southeastern Florida. Insects were from a laboratory colony established from *N. conspurcatalis* collected during late 2008 and early 2009 from Ivanhoe Falls, near Kununurra, western Australia (15°46'S, 128°44'E) (collection ABCL 2007046) and from near Litchfield National Park, Northern Territory (13°09'S, 130°38'E) (collection CSIRO(ADW)08-01), in the vicinity of locations where insects used in the initial TAG testing were collected. The first release in January 2008, consisted of 1,000 moths placed at a single site at the junction between cypress and pine flatwoods habitats (Table 1). Moths were transported to the site in metal screen cages and were released by opening cage doors and allowing moths to disperse naturally at the site. From March to June of 2008, multiple larval releases totaling 30,091 individuals were made at two other cypress sites (Table 1). Larvae on cut *L. microphyllum* foliage in plastic sandwich boxes were transported to field sites and distributed by manually inserting the clumps of caterpillar-infested foliage in between the climbing leaves of *L. microphyllum* plants growing at field sites (Boughton and Pemberton 2008).

Following releases, sites were monitored regularly. Site 1 was monitored seven times between January and July, and on six of these occasions, low numbers of *N. conspurcatalis* larvae or adults were found associated with small patches of feeding damage within a radius of about 25 m from the release point. At sites 2 and 3, life stages of *N. conspurcatalis* were detectable during the first few months, and by August, 3–5 months after releases were first made, moth populations had increased

Table 1. *Neomusotima conspurcatalis* release totals at *Lygodium microphyllum* sites in Jonathan Dickinson State Park in Florida.

Site	Habitat	Release period	Number of releases	Total released
Site 1	Cypress – pine flatwood interface	31 January 2008	1	1000 moths
Site 2	Cypress	31 March to 7 May 2008	3	14,791 larvae
Site 3	Cypress	22 May to 12 June 2008	8	15,300 larvae

markedly and were sufficiently large to have caused localized defoliation and browning of *L. microphyllum* patches in the vicinity of release points. When site 1 was next visited in October 2008, 9 months after the initial release, substantial amounts of larval feeding damage were apparent and clouds of moths were observed to take to the air when foliage was disturbed as researchers walked through the site. By November, very large populations of adults were present at sites 2 and 3, and large numbers of larvae at sites 2 and 3 had caused substantial defoliation and browning of *L. microphyllum* in the vicinity of release points (Table 2).

Observations indicated that defoliation damage was centered at release points and that this zone of defoliation slowly expanded outwards as infested plants were consumed and female moths dispersed outwards searching for fresh *L. microphyllum* plants on which to oviposit. Surrounding each defoliated zone was an 'active feeding zone', in which new larval cohorts were feeding. The areas of these zones were estimated by measuring outwards from the release point to the boundaries of these zones using a handheld Global Positioning System unit (Table 2). Indirect measures of moth abundance were made using 4-s sweep samples with a 38 cm diameter insect net when adult cohorts were present at sites, and yielded an average capture of 10.9 moths per sample (Table 2). Larval populations were estimated when larval cohorts were present at sites, by counting *N. conspurcatalis* caterpillars inside 0.5 × 0.5 m fixed quadrats which had been installed 20–60 m from release points in the months following initial releases. Across sites, the average larval density observed was 164.5 ± 54.6 larvae per quarter m<sup>2</sup> of lygodium foliage (Table 2). Using a conservative approach, in which it was assumed that only 50% of the *L. microphyllum* at sites was infested with *N. conspurcatalis* at the corresponding average density of 658 larvae per m<sup>2</sup>, the corresponding population estimates at sites 1, 3 and 2 in November 2008 were 1.6, 1.9 and 8.2 million larvae, respectively.

*Neomusotima conspurcatalis* is well established and has caused substantial damage to *L. microphyllum* at sites. Limited regrowth of the weed from dormant lateral buds has been observed following initial defoliation events, although observations indicate that this regrowth is subject to oviposition and subsequent rounds of larval defoliation. While it is still too soon to predict the long-term impacts of defoliation of *L. microphyllum* plants and populations by *N. conspurcatalis* in Florida, these early results look promising for the future of biological control of this serious invasive weed.

Table 2. Estimated population density of *Neomusotima conspurcatalis* and corresponding areas of *Lygodium microphyllum* colonized and defoliated as of November 2008.

Site	Area defoliated (m <sup>2</sup> )	Area of active feeding (m <sup>2</sup> )	Larval density Mean ± SE (No./0.25 m <sup>2</sup> ) <sup>a</sup>	Moth captures Mean ± SE (No./sample) <sup>c</sup>
Site 1	700	5000	— <sup>b</sup>	10.5 ± 2.4
Site 2	13,000	25,000	147 ± 84.3	11.2 ± 1.1
Site 3	1,200	6000	182 ± 81.2	—

<sup>a</sup>Based on assessment of four 0.5 × 0.5 m (0.25 m<sup>2</sup>) fixed quadrat locations per site.

<sup>b</sup>Foliage at the site was destroyed by frost before quadrats were colonized by larvae.

<sup>c</sup>Average based on 10 separate 4-s sweep samples at each site.

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